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Task 2: Study of Past Decontamination and Decommissioning Projects for DOE-RF D&D Support

E. R. Gilbert
R. P. Allen

August 1993

Prepared for the U.S. Department of Energy
Rocky Flats Office, Golden, Colorado
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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TASK 2:
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U.S. Department of Energy
Rocky Flats Office
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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

OBJECTIVE

The objective of this task is to extract and summarize information and lessons learned from past decontamination and decommissioning (D&D) projects applicable to D&D of plutonium-, uranium-, and beryllium-contaminated facilities at the Rocky Flats Plant. This report was prepared by Pacific Northwest Laboratory (PNL)[(a)] for the Rocky Flats Office of the U.S. Department of Energy (DOE).

KEY LESSONS LEARNED

Key lessons learned from published D&D projects' information and interviews with personnel experienced in D&D are summarized and presented under the headings of Planning, Quality Assurance/Safety/Documentation, Characterization, Dismantlement/Size Reduction, Decontamination, and Waste Management. Some of these key lessons learned are as follows:

- Start planning for the management of waste streams long before you start generating them. Developing management plans for "special-case waste" may take longer than generating it.
- Always, always, always expect and plan for the unexpected. Just like Cracker Jacks™, there is a surprise in every package! Don't work to the margins of your safety envelope.
- The D&D operations must be planned to ensure compliance with all applicable waste management criteria. The DOE/U.S. Nuclear Regulatory Commission (NRC)/U.S. Environmental Protection Agency/State/County/City release limits for separating wastes into categories of unrestricted recycle, low-level waste, transuranic (TRU), high-level wastes, etc., are not in agreement. Regulations from the different governments and agencies provide conflicting and inconsistent requirements. This may severely limit the general D&D approach as well as specific technology options.
- When planning for the management of waste it is important to recognize that often there are more stringent regulations for shipping hazardous and/or radioactive waste than for disposing of the waste.

(a) PNL is operated for the U.S. Department of Energy by Battelle Memorial Institute under Contract DE-AC06-76RLO 1830.

- During the planning stages, the project must anticipate regulatory changes and revised regulatory interpretations by the NRC, DOE, and U.S. Department of Transportation. Transuranic waste, for example, must be packaged either to comply with the Waste Isolation Pilot Plant (WIPP) and transuranic package transporter (TRUPACT) requirements in place at the time the shipment is to occur, or packaged in a manner that facilitates retrieval and repackaging. Considering the history of the WIPP-waste acceptance criteria and the TRUPACT-II authorized methods for payload control, the latter approach is recommended.

- Numerous hazardous materials such as lead, beryllium, mercury, and chromium, which tend to be common in facilities with radioactive materials, require special consideration to avoid generating mixed wastes during D&D operations. The WIPP does not accept mixed waste or TRU waste that contains combustible or gas-generating materials such as plastics, foam, etc.

- Former staff provide valuable insights. Past records of contamination and spills have been useful in planning decontamination procedures. The D&D planning requires characterization of contamination inventories and distribution. Industry is developing expertise in the area of decontamination and decommissioning. It is assuming a major role in the D&D of government facilities and can become an important factor in planning the resources for new projects.

- Provisions for containment, wherever loose radioactive material is handled, will provide significant savings in decontamination and cleanup costs. A large glovebox can effectively contain loose contamination during volume reduction operations. Temporary enclosures surrounding operations that could potentially prevent spread contamination are preferred to decontaminating newly contaminated areas.

- Continued surveillance is required for sites or buildings that are not decommissioned for unrestricted release and to ensure that underground contamination is not migrating.

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LIST OF ACRONYMS

ANL	Argonne National Laboratory
ANL M-III bins	20-y TRU waste retrievable packages storage by EG&G, Idaho
Ce(IV)	cerium in the valent state of 4
Ci	curies
cm	centimeter
D&D	decontamination and decommissioning
DF	decontamination factor
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DP	Defense Programs
dpm	disintegrations per minute
EM	Environmental Restoration and Waste Management
EPA	U.S. Environmental Protection Agency
ft	foot or feet
g	gram
h	hour
HEPA	high-efficiency particulate air
L	liter
LLW	low-level waste
μg	microgram
M	molar
m	meter
mrem	millirem
mCi	millicurie
NFS	Nuclear Fuel Services
NRC	U.S. Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
pCi	picocurie
PNL	Pacific Northwest Laboratory
ppm	parts per million
RFP	Rocky Flats Plant

CONTENTS

1.0 INTRODUCTION

1.1 OBJECTIVE

The objective of this task was to extract information and lessons learned from past decontamination and decommissioning (D&D) projects applicable to D&D of facilities at the Rocky Flats Plant (RFP) that are contaminated with plutonium, uranium, and beryllium.

1.2 BACKGROUND

Weapons production programs at the RFP are being terminated. Excess facilities and materials are scheduled for transfer to the U.S. Department of Energy (DOE) Environmental Restoration and Waste Management (EM) by the end of FY 1993. Declining budgets require optimization of proven D&D methods and the application of enhanced or new technologies to perform the D&D jobs faster, better, cheaper, and safer. To accomplish this, it is necessary to involve national laboratory personnel with extensive experience, innovation, capabilities, and expertise from industry and university resources. Technology enhancements are required in areas of contamination characterization, contamination removal, packaging, and transportation. Two specific requirements to minimize waste generation and to avoid mixed waste generation are superimposed on continuously changing regulatory requirements.

Even where it is not feasible to D&D the RFP buildings to the point of unrestricted release, they need to be refurbished for future DOE-controlled work, such as storing waste. Creating needed space without new construction, through removal and decontamination of equipment, has been demonstrated at several DOE sites. Section 2.0 provides a summary of the status of RFP facilities that require D&D and possible future use. These facilities include Buildings 771, 776/777, 779, 865, 886, as described by Science Applications

International Corporation (1992)[a] and Buildings 883, 444, 440, and 460 as described by Rocky Flats Plant (1992).[b]

A summary of past D&D experience pertinent to the RFP facilities listed in the paragraph above is provided in Section 3.0. A summary of lessons learned is presented in Section 4.0. A literature search (Villegas 1993) identified sites where D&D work has been completed or scheduled. Only facilities that have contaminants similar to those in RFP facilities to be decontaminated and decommissioned were selected for this study. Sites considered most relevant to the RFP facilities were those contaminated with plutonium, uranium, and beryllium. The approach taken was to extract and evaluate the information from the D&D reports and, wherever possible, to discuss the projects with personnel who were involved with the work. Rather than provide a summary of the numerous methods that have been attempted for decontamination, this report summarizes some of the methods that were found to be beneficial for these types of D&D projects. For a more complete treatment of decontamination tools and methods, the reader is referred to the Decommissioning Handbook (Manion and LaGuardia 1980) and other articles on decontamination techniques such as Allen (1985). The emphasis in this review is to describe the lessons learned from these past projects, demonstrations, and tests, to evaluate the lessons learned in the context of current requirements and regulations.

(a) Science Applications International Corporation (SAIC). 1992. Pre-Turnover Review of Rocky Flats Building 771, 776/777, 779, 865, and 886 Prior to Transfer from Defense Programs (DP) to Environmental Restoration and Waste Management (EM). Report with transmittal letter from S. A. Wiegman (SAIC) to Distribution, Richland, Washington.

(b) Rocky Flats Plant. Draft Revision 7 dated October 1, 1992. RFP Mission Transition Program Management Plan, Appendix A-2, Rocky Flats Plant, Golden, Colorado.

2.0 ROCKY FLATS PLANT FACILITIES THAT WILL REQUIRE D&D

The weapons production activities at the RFP have resulted in a number of the site facilities being contaminated with radioactive and/or potentially toxic materials. Specific buildings and their associated contaminants are described in this chapter. The information used as a resource for the preparation of Section 2 is cited in footnotes a and b on Page 1.2.

2.1 PLUTONIUM BUILDINGS

Building 771 was built in 1953 and has been used recently for safeguards and waste management. It has widespread contamination throughout the facility resulting from past radiological incidents. The process areas are contaminated with plutonium. Plutonium in glovebox exhaust ducts may exceed 400 g/line. The isolated pump room is heavily contaminated from pump gland leakage of plutonium nitrate solutions. Building 771 contains a radiochemistry facility for analyzing samples with a high plutonium content. It also contains an assay counter for plant high-efficiency particulate air (HEPA) filters. There is a building maintenance backlog. There are problems with the fire water main and inadequate fire suppression capability in some areas of the building. The analytical and assay counter work may need to be relocated. Building 771 could be used to provide D&D storage space.

Building 776/777 was constructed in 1953. Existing solid waste treatment facilities in Building 776/777 are anticipated to be suitable for future EM activities. The 776/777 Building is in good condition, but does not meet current structural standards. A large area of floor space that could be converted to storage is occupied by gloveboxes. The building interior, subroof, and some soil are contaminated from a 1969 plutonium fire. Loose contamination on some internal surfaces can exceed 10^6 dpm/100 cm^2. Some special nuclear materials in gloveboxes require stabilization. Building 776/777 could be used by EM for solid waste treatment. Floor space could be converted for storage.

Building 779 is in good condition structurally and has recently been upgraded to meet seismic and wind load requirements. All plutonium equipment,

gloveboxes, and ventilation systems are internally contaminated with plutonium. Residual contamination exceeding 10^6 dpm/100 cm^2 exists in some areas involved in past major contamination incidents. Radiation levels in some material storage areas exceed 100 mrem/h. Hardware has been targeted to be moved to Los Alamos. Special component testing equipment is to be moved to Los Alamos or Building 707. Special nuclear materials in gloveboxes require stabilization. Some ongoing activities are being continued and there is limited potential for future utilization aside from small scale analytical operations. Existing furnaces could be used for product stabilization or residue elimination. The facility would have to be upgraded before work could be started with plutonium-bearing materials.

2.2 ENRICHED URANIUM BUILDING

Building 886 has a thick shield wall for low-power critical experiments. The building is sound and watertight, but not up to current standards. Fissile materials and sources are stored. It contains 2700 L uranyl nitrate in tanks that are not in compliance with ANSI/ANS-8.5-1986. Security and monitoring upgrades are needed as well as building upgrades. The future of Building 886 is considered to be limited. A draft plan[(a)] has been prepared for disposition of the uranyl nitrates and resolution of noncompliance issues. An electrochemical ion exchange treatment of plutonium-bearing nitrate waste has been described by Atkins et al. (1992).

2.3 BERYLLIUM BUILDING

Building 865 was used as a non-plutonium industrial metal working facility. It has a 10-ton overhead lift. The building has been relatively well maintained, and the structure is in generally good condition. Problem areas are that it contains an undetermined extent of Be and U contamination, it contains a corroding Be electro-refining cell, depleted uranium storage is unshielded with exposure levels as high as 72 mrem/h at 6 ft from the wall,

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(a) EG&G. 1993. "Highly Enriched Uranium Solution Stabilization Program Management Plan." Draft. EG&G, Rocky Flats Plant, Golden, Colorado.

and unlined concrete is subject to contamination from waste. Building 865 has potential use for waste storage or waste handling. A mechanical press could be used for waste compaction. Furnaces and rolling mills may be used for melt refining of contaminated steel and fabrication of steel waste boxes.

2.4 DEPLETED URANIUM BUILDINGS 883 AND 444[a]

Depleted uranium parts for defense applications were formed in Building 883. The majority of the building's 76,500 ft^2 floor area is a high bay metal working facility containing large equipment, such as 2000-ton presses, rolling mills, furnaces, hot salt baths, and shearing machines. Depleted uranium has been processed in most of the process areas while enriched uranium has been processed only in the B side. The facilities have also processed beryllium. Within the building are also nine chemical waste tanks. Special nuclear material has never been handled or processed in Building 883. The building stores low-level radioactive scrap and packaged waste and is set up for performance of experimental decontamination demonstrations.

Although processing equipment is slightly contaminated with depleted uranium and/or beryllium, contamination containment was provided by a negative air pressure maintained in the building process areas, and a two-stage high HEPA filter filtered the building exhaust. Building 879 housed the filter plenum for the A and B sides of Building 883, and Building 827 contained the emergency generator for Buildings 865, 875, 883, and 889. Because of the large high bay areas with overhead crane coverage, Building 883 could become a warehousing waste storage facility.

The Building 444 Radiation Control Area consists of 143,140 ft^2 located in Buildings 444, 447, and 448. These areas contain highly specialized equipment and safety systems required to form, join, coat, and fabricate depleted uranium, beryllium, and other metals. Hazardous and mixed wastes generated by the processes are stored in controlled storage areas.

(a) Rocky Flats Plant. Draft Revision 7 dated October 1, 1992. RFP Mission Transition Program Management Plan, Appendix A-2, Rocky Flats Plant, Golden, Colorado.

The open access side of the Building 444 Complex has no radiological contamination and houses the Tool and Gage Shop, Tool Grind Shop, Erbia Coating Laboratory, and the administrative areas of the Building 444 Complex. The Building 444 Tool Shop provides tools, gages, and fixtures for the entire plant, including tooling for the Supercompactor, tamper-proof boxes for Selective Alpha Air Monitors, fixture supports for air pumps, and waste package fixtures and testing fixtures.

2.5 INDUSTRIAL FACILITIES BUILDINGS 440 AND 460

Building 440 was built in the late 1960s and is now part of the Rocky Flats Modification Center where vehicles are modified and repaired for the Transportation Safeguards Division of DOE, Albuquerque. Building 440 is a naturally ventilated high bay fabrication facility with structural steel construction, metal side walls, and over 41,000 ft^2 of floor space. It contains welding, machining, pipe fitting, metal working, insulation foaming, electrical, and painting operations, with a booth large enough to paint an entire tractor trailer. Building 439 is used as an ancillary machine shop. Only trace amounts of depleted uranium are anticipated during decontamination and disposition for both buildings. There may be residual chemical contaminants such as solvents and hydraulic fluids from processes such as painting and cleaning.

Building 460 is a modern non-nuclear manufacturing facility with a total area of 230,000 ft^2. The building is constructed of single-gabled, multi-span rigid-framed steel with concrete floors. The cooling process water supply and return is provided by Building 462. The facility provides manufacturing capabilities for forming, joining, heat treating, cleaning, and nondestructive testing. Small quantities of hazardous solvents, acids, cleaners, and heavy metal wastes are generated and collected in sump tanks for transfer to Building 374 for waste processing. Building 460 has never processed special nuclear materials, uranium, or beryllium. Continued operations are planned at least through FY 1994.

3.0 PAST D&D EXPERIENCE PERTINENT TO ROCKY FLATS PLANT

This section provides information on experience with decontamination and decommissioning of plutonium-, uranium-, and beryllium-contaminated facilities that should be relevant to RFP facilities contaminated with these materials.

3.1 EXPERIENCE WITH D&D OF PLUTONIUM-CONTAMINATED FACILITIES

Decontamination and decommissioning operations have been conducted at plutonium-contaminated facilities at Hanford (231-Z; 303-C; and 233-S Buildings), Mound Laboratory (Radioactive Processing Facilities), Argonne National Laboratory (Building 350), Nuclear Fuel Services' Erwin, Tennessee Plutonium Fabrication Facility, Battelle Columbus Laboratory's Plutonium Facilities, and Los Alamos Scientific Laboratory's Defense Programs' (DP) West Plutonium Facility. Technology development studies of D&D, including the decontamination of plutonium gloveboxes and other TRU-contaminated equipment, have been conducted at Hanford, Los Alamos, Rocky Flats, Savannah River, and by others.

3.1.1 Hanford 231-Z Plutonium Facility

Facility Description

The Hanford 231-Z facility is a 150- x 150-ft building constructed with reinforced concrete and concrete blocks. It was used as a plutonium metallurgical research and fabrication development facility for 30 years (King 1980) and contained 69 gloveboxes contaminated with plutonium oxide.

Restoration Project

Project objectives were to remove and dispose of all obsolete gloveboxes, related processing equipment, and contaminated services and utilities; to decontaminate the facility to levels as low a practicable; and to restore the facility for use as a multipurpose DOE research and development laboratory.

During the 1976-1978 period, 79 glovebox sections, associated piping, ventilation, duct work, and accessory equipment representing 16,000 ft^3 of disposal volume were removed. The residual plutonium in each item was

measured to provide a starting reference and basis for tracking decontamination progress. The piping, ventilation, and duct work were removed and secured by sealing open orifices and enclosing gloveboxes, piping, ventilation, ducts, and accessory equipment in plastic for contamination control. Gloveports and sectioned gloveboxes were closed with metal plates for contamination control.

After measuring the residual plutonium in each item, the material was placed in 23 large wood/metal boxes for retrievable storage at Hanford. Some ducting and other material was decontaminated to the low-level waste (LLW) category using electropolishing, but there was no effort, except for the external surfaces, to decontaminate the gloveboxes or other major equipment items.

Following removal of the gloveboxes and other contaminated equipment, the facility was further stripped, surveyed, decontaminated, and restored as a modern materials research laboratory. Some gloveboxes were retained to maintain a radiation work capability.

Problems/Successes

The restoration operation made approximately 20,000 ft^2 of laboratory space available for nonradioactive research work. The building was adequately cleaned for reuse by DOE programs. All surfaces were not stripped bare because of the uncertainty that some wall and floor areas may have had previously painted-over contamination. **Note: Use of improved characterization technology would reduce or eliminate these uncertainties.**

There were no major problems during the restoration operation. The work proceeded as planned except for the removal of two waste tanks, which were not emptied because of scheduling problems with another site contractor. There are, however, two areas where the operation did not conform to current standards. First, the disposal of contaminated gloveboxes and other equipment by emplacement in oversize retrievable storage boxes does not conform to current TRU waste transport and disposal criteria. It will be necessary to retrieve, remove, size-reduce, and repackage this material for final disposal.

Second, equipment containing hydraulic fluids was not drained and flushed as thoroughly as would be required by present regulations.

Lessons Learned

- D&D operations must be planned to ensure compliance with all applicable waste management requirements, e.g., TRU waste packaging, certification, storage, transport, and disposal criteria. These requirements may severely limit the general D&D approach as well as specific technology options.

3.1.2 Hanford 303-C Storage Facility

Facility Description

The 303-C Building was a facility used for storing plutonium oxide in the 300 Area at Hanford. An intensive decontamination effort was required to restore the building after the entire interior surface of the facility became grossly contaminated with plutonium from the rupture of a container of plutonium oxide (King 1980).

Decontamination Project

Project objectives were to secure the leaking package and restore the building for continued use as a storage facility. The site was first prepared for safe repetitive entries. Redundant two-stage greenhouses were established for contamination control during facility access. Personnel were assigned to assist in undressing, monitoring, and decontaminating staff. A portable operations control center was established for planning, dispatching, administering, and documenting the operations.

The leaking package was secured during an initial entry. A strippable fixative was used to secure the contamination for subsequent room entries, to prevent material from being resuspended, and to prevent the recontamination of clean surfaces. Movable equipment items were decontaminated to low levels of fixed contamination, coated with a fixative, wrapped in plastic, and placed in a box for disposal. The interior building surfaces were decontaminated, and any remaining areas of low-level contamination were documented and painted with yellow paint. A mechanical spalling tool (Halter et al. 1982) was used to remove the contaminated surface of the concrete floor.

Problems/Successes

The building was successfully decontaminated for continued use in storing plutonium oxide. Some of the technical and operational features that contributed to this success included the following:

- Use of a closed-circuit television to monitor all operations inside the facility. This increased efficiency substantially through improved communications among those performing and those directing the decontamination operations.

- Use of battery-powered air-purifying respirators to avoid dragging hoses around and resuspending the contamination, or carrying the weight of a portable air supply.

- Use of a strippable fixative as both a contamination control and a decontamination method. The horizontal surfaces in the facility were highly contaminated (up to 5×10^6 dpm/100 cm^2), resulting in gross contamination of personnel and resuspension of the oxide during the first entry. A strippable fixative was then applied to the floor, which substantially reduced personnel contamination during subsequent entries. Stripping the fixative reduced the smearable contamination to about 1×10^4 dpm/100 cm^2.

- Application of the fixative using a low pressure paint spray (pressure pot) system to minimize contamination resuspension.

- Use of a unique cheese-cloth technique to clean smooth vertical surfaces and difficult-to-access areas. The cheese cloth was hung from the vertical surfaces, sprayed with the fixative, which caused it to cling to the surface, and then stripped. Inaccessible ledges were decontaminated using the same approach, but employing a pipe to unroll and roll up the cheese cloth. **Note: The use of surface fixing films and strippable coatings is very useful for contamination control during D&D operations. However, at least some of these films are considered to be good neutron moderators, and disposal geometry can be a concern if these are stripped and wadded into a configuration that resembles a sphere. Criticality safety specialists should be consulted before using any of these films with fissile material. Also, the films may be considered a hazardous waste, and compatibility of the fixative with all waste disposal criteria must be addressed.**

The problems that were encountered during the decontamination operations that were not solved using the above approaches included:

- Resuspension of plutonium oxide trapped between the fixtures and the wall, causing a serious airborne problem.

- Extreme difficulty in decontaminating block walls. There were low-level spots that could not be eliminated without demolishing the wall. These spots were painted over with a yellow base warning coat and a finish coat.

Lessons Learned

- The use of a closed-circuit television to monitor D&D operations can significantly increase efficiency through improved communications among those performing and those directing the work.

- Where permitted, portable battery-powered air-purifying respirators can be used to avoid resuspension problems caused by dragging fresh-air hoses through contaminated areas, or carrying the weight of a portable air supply.

- Strippable fixatives can be very effective for contamination control and as a decontamination method to remove smearable contamination. A removable fixative applied to freshly decontaminated areas may prevent recontamination. Where necessary, fixatives should be applied using a low pressure paint spray (pressure pot) system to minimize contamination resuspension. The decontamination of smooth vertical surfaces and inaccessible areas can be facilitated by using cheese cloth that is sprayed with the fixative. Criticality safety concerns and waste disposal criteria must be considered when employing fixatives.

- Contamination that may be trapped between fixtures and the mounting surface can be resuspended during D&D operations, causing a serious airborne problem.

- The decontamination of block walls can be very difficult. There may be residual contaminated areas that cannot be eliminated without demolishing the wall.

3.1.3 Hanford 233-S Plutonium Concentration Facility

Facility Description

The 233-S Plutonium Concentration Facility was constructed in 1954 and 1955 to concentrate plutonium solution from the 202-S REDOX Building. A fire in 1963 created very high plutonium contamination levels in the building. The systems within the building were contaminated with transuranic elements, including plutonium, neptunium, and americium in pipes and vessels and in varying concentrations throughout the building in the forms of fixed and loose contamination. The 233-S facility was deactivated in 1967 when the 202-S REDOX facility was shut down. Process equipment and vessels were flushed with nitric acid for product removal. The status of the 233-S Plutonium

Concentration Facility has been described in a report by Kaiser Engineers Hanford Company (1992).

D&D Project

Decommissioning operations were conducted on the loadout hood within the 233-S Building (Shoemaker and Graves 1980). The loadout hood, which contained three cylindrical glass tanks and associated shielding, piping, and valves, was highly contaminated with transuranics from plutonium nitrate operations. Because of the highly contaminated environment, the plan was to clean the loadout hood surfaces to nondetectable surface contamination levels prior to dismantling. As a further protection for the decontamination personnel, radiological containments were designed, fabricated, and installed onto the face of the loadout hood. The decontamination and dismantlement work was performed through the containments using gloves.

Problems/Successes

The effort to decontaminate the loadout hood internal surfaces in place to nondetectable levels was not successful because of recontamination carried by the turbulent movement of 2600 cfm of air through the hood. The containment surfaces also became highly contaminated and eventual sources of recontamination. Fixation of surfaces was also incomplete because of recontamination during the fixation efforts. This was attributed in part to the difficulty of performing decontamination/fixation tasks while working through the containments.

The containments similarly decreased the efficiency of the dismantlement tasks. Maintenance operations, such as glove replacement, were frequently required and difficult to perform. Special dismantlement operations could not be performed because it was impossible to modify the containments.

Lessons Learned

- Efforts to decontaminate components to nondetectable levels prior to dismantlement is an inefficient approach and not required to maintain personnel protection and contamination control. A more efficient approach is to fix the smearable contamination, dismantle and remove the components, and then decontaminate the remaining surfaces.

- Radiological containments can be used for contamination containment and personnel protection. However, performing decontamination and dismantlement work through containment using gloves is arduous and decreases efficiency and effectiveness. Moreover, special containments are long lead-time items and cannot be readily modified to address special problems and tasks.

3.1.4 Mound Radioactive Processing Facilities

Facility Description

The D&D of the Plutonium Processing Building, Research Building, Special Metallurgical Building, and the Waste Transfer System included cleaning and removal of internal glovebox equipment and services, removal of gloveboxes, removal of associated laboratory equipment and services, structural decontamination, and disposal of wastes.

Restoration Project

The project objectives were to decontaminate and decommission radioactive processing facilities with no significant personnel exposures or environmental releases.

Problems/Successes

Radioactive material processing facilities at Mound have been decontaminated and decommissioned with no significant personnel exposures or environmental releases (Garner and Davis 1975). Work has involved materials contaminated with isotopes of ^{210}Po, ^{226}Ra, ^{227}Ac, and ^{238}Pu. Additional D&D has been performed on the plutonium processing building, research building, and the waste transfer system (Combs et al. 1982 and Bond et al. 1987). In 1972, D&D had been completed on the Special Metallurgical Building that housed the ^{238}Pu process for the fabrication of radioisotopic-fueled heat sources (Harris et al. 1974). Methods used have included coating with urethane foam, entombment, removal, foaming, bagging, tents, chutes, portable exhausters, dry ice, vents, bubble suits, three-zones, fire watches, painting and sealing, in-line cleaning, high pressure water blaster, and chemical cleaning.

Radioactive materials have been removed from gloveboxes, equipment, and piping by standard cleaning and flushing techniques. Temporary enclosures, fixation, and ventilation were applied to control contamination during

subsequent removals. Fixation included light water misting to contain dust, strippable paint to temporarily fix surfaces prior to final decontamination, and urethane foam to fix inside surfaces of gloveboxes after equipment, piping, and other services were removed. The fixative minimized the potential for contamination spread during glovebox separation, packaging, and shipment. Strippable paint was not used because of potential long-term radiolysis of the paint inside the gloveboxes. A one- to two-inch layer of foam was used to minimize future potential waste-reprocessing problems at the burial storage facility. The urethane foam provided a contamination barrier during subsequent cutting and was applied at the four corners, middle of the side, and top in the waste package. Plasma cutting reduced smoke generation over standard torch cutting methods, minimized heating, and provided smooth edges. A three-zone concept was used for contamination control.

Unrestricted release without demolition was not feasible because of known and potential contamination in structural members, underneath the facilities, and in cracks and crevices. Because the buildings would continue to be used for DOE programs, complete demolition was not considered. The D&D performed on the Special Metallurgical Building reduced the ^{238}Pu content from 100,000 Ci to less than 0.3 Ci without a significant release to the environment.

Lessons Learned

- Materials such as strippable paint that may be subject to long-term radiolysis during TRU waste disposal should not be included in the final waste package.
- In cases where decontamination methods are ineffective in adequately reducing contamination levels in gloveboxes, contamination fixation may effectively be used to control the spread of contamination during glovebox, equipment, and piping removal.
- Contamination in cracks and crevices made it difficult to achieve building goal average contamination levels of

wipe:	$\leq$20 dpm/100 cm^2
direct:	$\leq$1500 dpm/100 cm^2
external radiation at surface:	$\leq$1 mr/h

- Plasma cutting of gloveboxes generates less smoke than torch cutting.

- The use of independent contractors to verify remaining contamination provides assurance of monitoring results and additional documentation for future reference.

- **Note: Before using foam or strippable paint as a fixative or packing additive, materials permitted in transport and disposal of TRU waste materials must be reviewed. More effective methods for decontamination and size reduction may now be available.**

3.1.5 Argonne National Laboratory Plutonium Fabrication Facility

Facility Description

Building 350 was constructed to house the Plutonium Fabrication Facility and became operational in 1959. It was used extensively for 15 years to develop methods of alloying, casting, machining, cladding, and assembling fuel elements containing plutonium. The facility contained a variety of equipment, from small-scale laboratory instruments to full-scale rolling mills, machine tools, metal plate shear, hydraulic presses, and a variety of furnaces. This equipment was enclosed within a modular system of specially designed gloveboxes. Specific types of equipment were assembled into individual glovebox lines, and the glovebox lines were interconnected through a central conveyor system approximately 100 ft long. The facility was used to process hundreds of kilograms of ^{239}Pu in metallic and ceramic form, as well as lesser amounts of ^{235}U.

Restoration Project

The objectives were 1) to decontaminate and decommission the surplus Plutonium Fabrication Facility, including the glovebox room, fan loft and service floor, to allow usage of the building space by the New Brunswick Laboratory (Wynveen et al. 1982); and 2) to remove the hazard for dispersal of residual plutonium from contaminated equipment in the event the facility were subjected to a tornado or other destructive event. The gloveboxes were contaminated with various levels of alpha contamination, some of which exceeded 10^9 dpm/100 cm^2. Up to 200 g of plutonium was distributed throughout the gloveboxes.

Problems/Successes

The surplus Plutonium Fabrication Facility, including the glovebox room, fan loft, and service floor in Building 350, was decontaminated and decommissioned (Argonne National Laboratory 1979; Kline et al. 1982; Kline et al. 1985). The work required dismantling and removing interior equipment followed by decontamination, painting, and size reduction of all gloveboxes. The ventilation ductwork, filter banks, utility systems and associated equipment components were also removed. Some operations were transferred to the Fuels Technology Center in Building 212.

Work at ANL (Januska et al. 1974) demonstrated that a brief single wiping of a heavily plutonium contaminated glovebox with Calgon Hel-Cat™, Myco Tiara™, or Pennwalt 2187™ could reduce the smearable contamination with a decontamination factor (DF) of 20 down to 1 to 10,000,000 dpm/100 cm^2. The TRU waste was placed in ANL M-III bins, a type of 20-year TRU waste retrievable package approved for storage by EG&G Idaho Inc. Gloveboxes were reduced in size to fit into this standard 1.2- x 1.5- x 1.8-m bin by disassembling and cutting within a temporary plastic enclosure. The volume of retrievable TRU waste generated was 14,000 ft^3. Space made available from decommissioning was used for activities transferred from the New Brunswick Laboratory in New Jersey.

The most difficult problems encountered were 1) handling and removing large and heavy components from gloveboxes, 2) size reduction of gloveboxes and components for placement into the M-III bin, 3) selection of protective clothing and respirator equipment, and 4) direct-reading instrumentation for assay.

Lessons Learned

- Contamination holdup in inaccessible surfaces may prevent decontamination to less than TRU waste levels.
- The removal of large components from gloveboxes without spreading loose contamination can be accomplished through a bagout port.
- Temporary enclosures can be used to control contamination during size reduction operations (technology transferred from RFP (Kline et al. 1982)).

- Residual contamination and TRU waste content could be measured using procedures developed for direct-reading assay instruments.
- To increase the odds of not missing contamination, all surfaces were surveyed at least three times with three portable instruments having different detection characteristics.[a]
- **Note: The ANL M-III bin may not be in compliance with the final TRU waste disposal facility and therefore the contents may require further size reduction and repackaging.**

3.1.6 Nuclear Fuel Services' Erwin, Tennessee Plutonium Fabrication Facility

Facility Description

The NFS plutonium fabrication facility in Erwin, Tennessee, had 10,500 ft^2 of floor space and 136 gloveboxes in two separate buildings on the NFS-Erwin site.

Restoration Project

The primary objective of this D&D project was to restore the existing facilities and site to levels of contamination which permit unrestricted use. All D&D operations and shipment of TRU waste were to be completed by April 15, 1992; however, completion has been extended to June 1994. Facilities requiring D&D included gloveboxes, process equipment, ventilation

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(a) The three portable instruments were

1) a rate meter with a thin (0.85 mg/cm^2) window, 61 cm^2 area gas-flow proportional detector for measuring the $\alpha\beta\gamma$ surface contamination - It was operated on the β plateau for $\alpha\beta\gamma$ detection.

2) a rate meter with a thin (0.85 mg/cm^2) window, 61 cm^2 area gas-flow proportional detector for measuring the α surface contamination - It was operated on the α plateau for α detection.

3) a single channel pulse height analyzer with 2 mm by 50 mm diameter NaI(Tℓ) detector for optimum detection of low energy photons - The single channel analyzer was calibrated to operate in three gross modes; one with threshold at 17 keV (plutonium L X-ray), a second with threshold at 60 keV (^{241}Am), and a third with threshold at 186 keV (^{235}U). It could also be used in three pulse height analysis modes for the same energies listed. The energy width of the analyzer was set at 25% of the selected photon energy.

ductwork, piping, conduit, scabbed concrete, and soil (Hunt, Paine, and West 1990). EcoTek, Inc. was contracted in July 1987 to manage the decontamination and decommissioning of this plutonium fabrication facility.

Problems/Successes

The NFS contract with DOE limited the amount of TRU waste that could be shipped during the 10-year contract to a total of 5,500 ft^3. Therefore, to minimize the volume of waste shipments and keep the TRU waste volume below 5,500 ft^3, waste processing strategy consisted of

- decontamination and sectioning with an ultra-high-pressure water jetting system incorporating a recirculating medium
- volume reduction in a high-capacity shear/baler
- and material control accountability utilizing a five-station, active-passive neutron nondestructive assay system.

A stainless steel containment was constructed to house the sectioning and decontamination station. This containment attached directly to the shear/baler, which was modified to encapsulate all surfaces subject to contamination.

The five-station active-passive neutron nondestructive assay system consisted of 1) pre-decontamination inventory, 2) decontamination assay, 3) nuclear safety and accountability monitoring system, 4) bale and drum counter, and 5) bulk mixed uranium-plutonium oxide assay system.

The task was streamlined through the use of the automated waste handling decontamination and volume reduction facility that was designed and built to provide accelerated processing of contaminated equipment with less personnel exposure than the traditional manual sectioning and packaging techniques. Process equipment has been removed; work is progressing on the release of soils, walls, and building structures. Some of the ventilation equipment has been removed. Approximately 200 m^3 of gloveboxes, laboratory equipment, fuel process equipment piping, and duct work have been successfully processed through decontamination and volume reduction. Nondestructive assay successfully separated and classified waste packages. Up to 25% of the total waste volume processed has been certified as Class A LLW (West et al. 1991).

Lessons Learned

- Initial assay characterization of the radioactive materials is very important. Planning must include contingencies to deal with unexpected materials, e.g., plutonium fluoride where plutonium oxide was expected.
- The development of a nondestructive assay capability enabled separation and classification of waste packages.
- Provisions for containment, wherever loose radioactive material is handled, will provide significant savings in decontamination and cleanup costs.

3.1.7 Battelle Columbus Laboratory Plutonium Facility

Facility Description

The Battelle-Columbus plutonium facility was a contract research and development laboratory covering 5350 ft^2 and contained 28 gloveboxes and 2 fume hoods. It was contaminated with both ^{239}Pu and ^{238}Pu.

Restoration Project

The objectives of the Battelle Plutonium Laboratory Decontamination Program were to release 28 gloveboxes and fume hoods as LLW, decontaminate and remove auxiliary systems, and restore the facility for unrestricted use.

Problems/Successes

The Battelle Plutonium Laboratory Decontamination Program was started in 1978 and involved

- program planning and preliminary laboratory cleanup
- removal of bulk special nuclear material
- decontamination and removal of all gloveboxes
- decontamination and removal of the auxiliary systems
- decontamination and removal of the contaminated drain and holding tank system
- decontamination of the interior walls
- packaging, transportation, and burial storage of wastes
- restoration of the building lighting and ventilation systems

- certification of compliance with ANSI N13.12 and Attachment A, to NUREG-0436, dated March 1978.

Because of crevices and hold-up points, attempts to decontaminate 28 gloveboxes and fume hoods previously used for plutonium work for release as LLW <10 nCi/g were abandoned (Freas and Madia 1982). Instead, in controlled atmosphere tents, the units were cut into small pieces for volume reduction, triple-bagged in polyethylene, and placed in M-III metal bins and 55-gal drums as high-level waste. No TRU waste was noted by Freas and Madia (1982). Laboratory areas were decontaminated by scrubbing, high-pressure water rinsing, and sandblasting.

Lessons Learned

- Because of crevices and hold-up points it may not be feasible to decontaminate gloveboxes for release as LLW.
- Volume reduction can be accomplished by reducing gloveboxes and equipment into small pieces and loading them into 55-gal drums.

3.1.8 Los Alamos Defense Programs' West Plutonium Facility

Facility Description

The DP West Plutonium Facility that had been used to produce plutonium metal and fabricate parts for nuclear weapons from 1944 to 1945 and then used as a plutonium processing and research facility until 1978 was decontaminated (Garde et al. 1982a, 1982b).

Restoration Project

The objective was to decontaminate three buildings and portions of three others, a total floor space of 5330 m^2, to a level that would allow continued occupancy for nonplutonium research operations.

Problems/Successes

Decontamination operations required dismantling and removing gloveboxes and conveyor tunnels; removing process systems, utilities, and exhaust ducts; and decontaminating all remaining surfaces. A procedure was developed for glovebox decontamination.

Past records of contamination and spills were used for planning the building decontamination work. Equipment and building services were removed, contaminated non-load-bearing walls and ceilings were removed. Building surfaces and service systems were decontaminated by damp wiping or mopping. Surfaces were painted and new linoleum was installed for new occupants. Contaminated concrete surfaces were removed by scarifying.

Plutonium gloveboxes would have to be decontaminated to <10 nCi ^{239}Pu or <100 nCi ^{238}Pu per gram of waste to permit nonretrievable shallow trench disposal. However, because plutonium was retained in cracks, corners, and other shielded hold-up areas, nonretrievable disposal was abandoned. Even though one acid wash-water rinse removed approximately 85% of the plutonium in a glovebox, still >10 nCi ^{239}Pu per gram of waste remained. Surveys indicated that glovebox contamination levels could be reduced to a nonretrievable level by numerous wash cycles, but large volumes of waste solutions would be generated, and the limited project funding and schedule would not support decontamination to the nonretrievable level. The gloveboxes were stored as retrievable TRU waste. The gloveboxes were separated and packaged in bolted metal containers. The retrievable waste consisted of 1488 m^3 of gloveboxes and conveyor tunnels; 166 m^3 pipe, duct, etc.; and 104 m^3 soil.

Lessons Learned

- Planning the building decontamination work is much more effective if past records of contamination and spills are evaluated.
- Plutonium in hold-up regions can be very difficult to remove.
- Even though decontamination to nonretrievable storage levels may be possible, the volume of liquid wastes generated, as well as time and cost may be prohibitive.
- Scarifying may be required to decontaminate concrete surfaces.
- **Note: Operations of D&D must be planned to ensure compliance with all applicable waste management requirements, e.g. TRU waste packaging, certification, storage, transport, and disposal criteria. These requirements may severely limit the general D&D approach as well as specific technology options.**

3.2 D&D TECHNOLOGY DEVELOPMENT AND DEMONSTRATION PROJECTS

Projects that developed and demonstrated decontamination technology such as: decontamination of gloveboxes, decontamination using Ce(IV), an application of decontamination using Ce(IV), decontamination by electropolishing, reuse of electrolyte, electrolytic decontamination using nitric acid, decontamination using neutral electrolytes, and decontamination by vibratory finishing have significantly contributed to D&D of facilities.

3.2.1 Savannah River Site Glovebox Decontamination

Project Description

Two gloveboxes that had been used for 12 years in handling transuranic nuclides (Crawford 1978) at the Savannah River Site (SRS) were decontaminated in a test program to collect data for developing a decontamination facility for large equipment highly contaminated with alpha emitters. The objective was to demonstrate the feasibility of a method for decontaminating plutonium-contaminated gloveboxes to TRU waste levels of <10 nCi/g to permit disposal as LLW.

The two 4- x 5- x 6-ft gloveboxes contained furnaces, centrifuges, and other miscellaneous items that had been used to process solutions and solid compounds containing multi-gram quantities of ^{238}Pu, ^{239}Pu, ^{243}Am, ^{244}Cm, and up to 100 μg of ^{252}Cf. Solutions contained 10^{10} dpm/cm^3 of ^{238}Pu. A preliminary survey revealed approximately 1.6 and 4.8 Ci of TRU waste in the two boxes. Radiation intensities were as high as 2 mR/h at the exterior surfaces of the boxes.

Problems/Successes

After the inner surfaces were vacuumed and washed with detergent, the TRU waste inventories were reduced to approximately 1.3 and 3.4 Ci. Decontamination consisted of a cycle of water flushes and alkaline permanganate and oxalic acid washes. One glovebox was decontaminated from 1.3 Ci to 5 mCi (6 nCi/g) using 1.3 gal of 3 wt% potassium permanganate with 16 to 18 wt% sodium hydroxide decontamination solution and a 15 wt% oxalic

acid wash. Decontamination required 0.03 manhour per square ft of surface area. The second glovebox was decontaminated from 3.4 Ci to 2.8 mCi (4.2 nCi/g) using 0.9 gal of decontamination solution and 0.02 manhour per square ft of surface area.

These tests demonstrated that gloveboxes and similar equipment grossly contaminated with transuranic nuclides can be decontaminated in situ to TRU waste levels of <10 nCi/g with a moderate amount of decontamination solution and manpower. Both gloveboxes were decontaminated to the level required for disposal as LLW. This work also demonstrated that obsolete gloveboxes, cell liners, and other bulky containment equipment occupy inordinately large volumes when stored in a retrievable mode. Decontamination of such equipment below 10 nCi/g can reduce retrievable storage space and costs. **Note: Since this work was conducted, the concentrations defining TRU waste have changed to <100 nCi/g.**

Lessons Learned

- Accurate characterization of the initial concentrations and location of contaminants aids in monitoring the progress of the decontamination operation.
- In situ chemical decontamination techniques can be used to convert Plutonium-contaminated gloveboxes to the LLW category.
- Without protection, monitoring instruments can become contaminated. A thin polyester film can effectively protect instruments.

3.2.2 Decontamination Tests Using Ce(IV)

Dissolution rates of approximately 1.5 mm/h surface from stainless steel were demonstrated with Ce(IV) nitric acid solutions (Partridge and Lerch 1979). Plutonium contamination >500,000 dpm on stainless steel was reduced to nondetectable levels in 1 hour at 90°C.

Suwa et al. (1986) found that 0.0013-0.010 M Ce(IV) in sulfuric acid solutions dissolved Cr, Fe and Ni in Cr-rich oxides. The DF was about 33 in 0.25 M sulfuric - 0.005 M Ce(IV) after 24 h at 90°C.

3.2.3 Hanford Critical Mass Laboratory Tanks

Project Description

Five stainless steel vessels from the Hanford Critical Mass Laboratory were decontaminated to non-TRU waste levels using the Ce(IV) process developed by Bray (1988). The tanks ranged in size from 5 gal to 67 gal, and one of the tanks was filled with stainless steel rashig rings. The tanks contained from 0.4 to 176 grams of plutonium. The tanks were decontaminated using 0.5M nitric acid containing ceric nitrate.

Problems/Successes

The Ce(IV) decontamination demonstration was successful. The tanks, including those that were heavily contaminated or filled with rashig rings, were decontaminated to <100 nCi/g levels, permitting their direct disposal as LLW.

Lessons Learned

The Ce(IV) decontamination process can decontaminate stainless steel to plutonium levels permitting disposal as LLW. Although this approach can be used for immersion decontamination applications, it may be particularly useful for the in situ decontamination of tanks and piping.

3.2.4 Decontamination by Electropolishing

Arrowsmith and Allen (1978) found electropolishing to be the only method that consistently reduced surface contamination levels to background. The use of a phosphoric acid electrolyte ensured containment of the contamination removed by electropolishing, and produced a polished surface that facilitated rinsing. High dissolved metal concentrations degraded the performance of electrolytic solutions. Comparison studies showed that DF values >100,000 were reasonable for electropolishing, >2,000 for liquid honing, and >200 for vibratory finishing. These processes can be scaled up and automated to reduce schedule and labor requirements.

3.2.5 Reuse of Electrolyte

To maintain efficiency when reusing chemical decontamination solution for electrolytic polishing decontamination, Onuma et al. (1989) removed permanganate ions (MnO_4).

3.2.6 Electrolytic Decontamination Using Nitric Acid

Plutonium nitrate contamination (0.5 $\mu g/cm^2$) was removed electrolytically with decontamination factors of 100 to 1000 depending upon the nitric acid electrolyte that was used (Turner et al. 1983). Unstirred electrolytes of 1M HNO_3, 1M HNO_3/0.1M NaF, and 5M HNO_3 performed best. Only stirred 5M HNO_3 showed a slight improvement. Electrolyte throwing power and substrate surface roughening compromised performance.

3.2.7 Decontamination Using Neutral Electrolytes

A sodium nitrate-borax solution was shown to be a good medium for electro-decontamination (Kazanjian and Killion 1979). Plutonium recovery was easier and less waste was generated than with acidic electrolytes. Chromium did not precipitate in this solution and was periodically removed to maintain electrolytic efficiency. Use of phosphoric acid was discontinued because it was not recyclable. A nitric acid-borax solution resulted in the generation of large volumes of liquid waste. Plutonium was separated to less than 0.01 g/L from the impurities using Dowex 11 anion exchange resin. **Note: Tests of the neutral electrolyte at Pacific Northwest Laboratory (PNL) indicated that the current density requirements were so high that the electrode size required to conduct the power was too large for feasible application. Also, weld areas were not effectively decontaminated by the neutral electrolytes.**

3.2.8 Decontamination by Vibratory Finishing

Vibratory finishing is a decontamination process capable of converting large volumes of surface-contaminated TRU waste to non-TRU waste levels with minimal generation of secondary waste (McCoy, Arrowsmith, and Allen 1980). Key advantages of this decontamination process include

- Vibratory finishing will remove TRU waste contamination from almost all classes of metals and alloys and from a wide range of surface-

contaminated nonmetallic TRU waste including plastic, glass, and rubber. Typical glovebox materials that have been decontaminated to below TRU waste levels include stainless steel panels, glass containers, plastic gloveport rings, rubber gaskets, rubber glovebox gloves, and even plastic bagout bags.

- Vibratory finishing rapidly decontaminates both surface-contaminated metallic and nonmetallic waste to well below TRU waste levels, usually less than 0.2 nCi/g, permitting immediate reclassification to the LLW category. The small amount of contamination that remains is primarily fixed contamination, so that the decontaminated material is basically nonsmearable to facilitate the handling, transportation, and disposal of the processed waste.

- Vibratory finishing can achieve substantial waste volume reductions. A reduction of more than 95% in the volume of TRU waste requiring interim storage and eventual geologic disposal has been achieved for typical plutonium-contaminated gloveboxes.

Vibratory finishing has been successfully developed from a laboratory demonstration to a pilot scale operation (McCoy et al. 1982). Vibratory finishing has also been found to be an effective cleaning process for a variety of radioactively-contaminated soils (McCoy 1983). Many soil contaminants, including corrosion products, scale, oil, grease, and paint, were removed by the vibratory finishing process.

3.3 EXPERIENCE WITH D&D OF URANIUM-CONTAMINATED FACILITIES

Experience with decontaminating and decommissioning uranium-contaminated facilities has been obtained in the U.S. with the Cimarron Facility operated by the Sequoyah Fuels Corporation in north central Oklahoma, with the General Electric Fuels Laboratory at Vallecitos, California initiated in 1979, the New Brunswick Laboratory in New Jersey initiated in 1981 by Argonne National Laboratory, and the Compton, California, uranium-contaminated facility.

3.3.1 Cimarron Uranium Facility

Facility Description

The Cimarron Facility was operated by the Sequoyah Fuels Corporation in north-central Oklahoma. It contained separate plutonium and enriched uranium fuel fabrication plants (Adkisson 1987). The site also contained small

settling lagoons and a small shallow burial area used to dispose of uranium- and thorium-contaminated wastes.

The plutonium fuel fabrication plant contained stainless steel gloveboxes, tanks, piping, and ventilation ducts that required decontamination. These had been used to co-precipitate plutonium and uranium nitrate solutions, to press mixed-oxide powders into pellets, and to load fuel pins.

Restoration Project

The objective of the decommissioning activity was to decontaminate the facilities for termination of the NRC licenses with no restrictions on future use of the property. The decommissioning work involved 1) decontamination of the plutonium fuel fabrication plant, 2) decontamination of the enriched uranium fuel fabrication plant, 3) excavation, packaging, and shipment of the lagoon sediments and associated underground piping, and 4) excavation, repackaging, and shipment of the LLW to the burial ground.

Problems/Successes

For plutonium facility work, a large glovebox was modified and converted into a working vessel for dismantling and cutting equipment. This box provided ventilation, containment, smoke control, and personnel shielding while a plasma-arc unit was used to cut other gloveboxes, process equipment, piping, tanks, and similar stainless steel items into small <14-in. pieces. The pieces were assayed for plutonium. The approach provided contamination and exposure control, volume reduction of TRU wastes, packaging, compaction, and selective loading for transportation. This operation accomplished volume reduction from 30,000 ft^3 of gloveboxes, tanks, process equipment, laboratory equipment, associated items, and 1 mile of Schedule 80 process piping down to 9,000 ft^3 of retrievable TRU waste and 13,000 ft^3 of LLW. Over one million dollars worth of equipment was transferred for reuse.

For uranium facility work, equipment was decontaminated to levels that allowed its release and reuse at other facilities.

For decommissioning the two small lagoons used for uranium processing, a new synthetic-lined lagoon was constructed to receive the process wastes and

the inventory of liquid from the older lagoon. Twelve inches of sediment were removed from one lagoon and eighteen inches from the other. These sediments were packaged in drums and shipped to a LLW disposal site.

Approximately 1.5 Ci of enriched, natural, and depleted uranium and natural thorium wastes, buried prior to 1971 in accordance with 10 CFR Part 20, are being removed to permit release of the site for unrestricted use. The wastes are being repackaged in 55-gal drums and assayed.

Lessons Learned

- Experienced personnel have been very important to the success of D&D operations.
- A large glovebox can effectively contain loose contamination during volume reduction operations.
- During decommissioning, construction of a new synthetic-lined lagoon can be very effective for temporary placement of process wastes removed from a lagoon contaminated from uranium processing.

3.3.2 General Electric Vallecitos Nuclear Center Fuels Laboratory

Facility Description

The Fuels Laboratory at the General Electric Vallecitos Nuclear Center near Pleasanton, California was used for mixed-oxide $(Pu+U)O_2$ fuel fabrication and development since 1962. Principal functions included 1) the fabrication of test and demonstration fuel for six test reactors and four commercial reactors; 2) development and demonstration of innovative processes for plutonia and urania-plutonia conversion, mixed-oxide fuel fabrication, fuel rod and bundle fabrication, scrap recovery and recycle, and material property studies; and 3) specialized activities such as inspection and coating of the SNAP 27 power source for the Apollo Moon Missions (Thompson and Kurtz 1982). The processing area included gloveboxes, fume hoods, and associated equipment occupying over 4000 ft^2 of floor area.

Restoration Project

Decontamination and decommissioning activities were initiated in 1979.

Problems/Successes

Special nuclear materials were removed and shipped. Numerous decontamination methods were tested. Process equipment was cleaned, removed from gloveboxes, assayed, and packaged for disposal. Wastes were separated into low specific activity and retrievable TRU waste in 55-gal drums. Oversized gloveboxes, fume hoods, and other equipment were loaded into GE Model 9136 shipping packages, foamed in place, and shipped as retrievable TRU waste. The laboratory surfaces were decontaminated to ≤20 dpm/100 cm^2 and direct probe readings were ≤100 dpm/100 cm^2 average and 300 dpm/100 cm^2 maximum.

Lessons Learned

- A requirements analysis was found to be very valuable in avoiding difficult situations during decommissioning and ensuring that waste packages could be shipped for disposal. The requirements analysis clearly identifies all requirements related to burial, shipping, packaging, decontamination, characterization, equipment removal, and other program operations. The requirements should be considered in this specific order to ensure that the end product of the D&D operations is a waste package that can be buried or stored for later retrieval.

- The work will progress much more smoothly if the waste package designs are reviewed with all interested parties e.g., DOE, U.S. Department of Transportation (DOT), and NRC.

- During the planning stages, the project must be prepared for regulatory changes and revised regulatory interpretations by NRC, DOE, and DOT.

- Because facilities and equipment are generally not designed for D&D, careful reviews are necessary to determine the D&D methods that will be successful. Design of future equipment and facilities should incorporate D&D requirements.

- Decontamination is feasible with limited quantities of liquids, but requires innovative tools and techniques. Preliminary tests and demonstration of methods are essential. Experienced personnel are important.

3.3.3 New Brunswick Laboratory in New Jersey

Facility Description

The New Brunswick Laboratory in New Jersey (Wynveen et al. 1982) was comprised of a large main building, a plutonium laboratory complex, a hot-cell building, and nine ancillary structures on a 2.3 hectare site. The facilities

were operated from 1948 to 1977 as a general nuclear chemistry facility. Its main functions had been to prepare standards for nuclear materials assay, pilot-plant thorium extraction, and UF_4 production.

Restoration Project

In 1981, Argonne National Laboratory was commissioned by DOE to decontaminate and decommission the New Brunswick Laboratory. The objective of the D&D was to release the facilities for unrestricted use. The release criteria in dpm/100 cm^2 in smearable and fixed were 20 and 100 for transuranics; 200 and 1000 for thorium, strontium, radon, ^{232}U and iodine; and 1000 and 5000 for other uranium isotopes and associated decay products. Several spills had occurred during 29 years of work with thorium and uranium ores, high purity plutonium, and uranium enriched in ^{233}U and ^{235}U. Contaminated liquid waste had been discharged into the sanitary waste system in accordance with then applicable concentration guides.

Problems/Successes

A detailed radiological characterization detected residual surface contamination up to a few thousand dpm/cm^2 of uranium, thorium, and americium, and trace amounts of cesium, strontium, radium, and yttrium in several buildings. Two major difficulties were assuring detection of alpha contamination under painted surfaces in the plutonium area and maintaining high sensitivity gas-flow proportional survey instruments. Because of radioactive contamination detected in the plaster and foundation, it was decided that it would not be cost effective to decontaminate the structures for unrestricted use. The structures were not demolished, but dismantled wall-by-wall and, in some cases, block-by-block to avoid losing identified areas of contamination and also to permit the survey of hidden surfaces. All objects above the contamination criteria were placed directly into shipping bins. Materials below the contamination criteria were sent to the local landfill. Materials that could not be internally surveyed, but had potential for contamination, were treated as contaminated.

Contaminated portions of walls, floors, ceilings, and plutonium waste hold-up tanks were also removed. The decontamination work was completed in

seven months, but the D&D did not include the removal of the concrete pad of the main building that contained the contaminated sewer lines.

Lessons Learned

- To increase the odds of not missing contaminants, all surfaces should be surveyed at least three times with three portable instruments having different detection characteristics.
- Sites that cannot be decommissioned for unrestricted release require continued surveillance to ensure that underground contamination is not migrating.

3.3.4 Compton, California Uranium Contaminated Facility

Facility Description

The Compton, California, depleted uranium manufacturing facility, in operation from 1977 to 1986, was decommissioned for unrestricted use (Bernhardt et al. 1987; Bernhardt et al. 1989; Cole et al. 1989) in accordance with the U.S. NRC Guide 1.86. The facility was a 62,400 ft^2 masonry structure with a concrete slab grade.

Restoration Project

The objective of the D&D of the depleted uranium manufacturing plant was to release the facility to its lease holder for unrestricted use. Rogers and Associates Engineering Corporation was commissioned to manage the decontamination and certification of the cleanup of the Compton uranium contaminated facility.

Problems/Successes

The removal of government-owned equipment in the facility and the decontamination was performed by a contractor. The decontamination criteria based on California, U.S. Environmental Protection Agency (EPA), and NRC standards are: a removable contamination limit determined by smearing with a dry filter of 1,000 dpm/100 cm^2; an average total contamination, based on a maximum area of 1 m^2 of 5,000 dpm/100 cm^2; and a maximum total contamination, based on an area of not more than 100 cm^2 of 15,000 dpm/100 cm^2.

The facility and its associated contamination was characterized. Smears on recently cleaned floors measured around 3000 dpm/100 cm^2, while smears of

small pits in the concrete surface measured above 15,000 dpm/100 cm^2. Scrubbing, strippable paint, and a Turco™ acid wash reduced the contamination in some areas, but some values remained above 15,000 dpm/100 cm^2. Soil under the slab taken from joints, cracks and expansion joints ranged from 10 to 100 pCi/g. Contamination on the cardboard insulation in the ceiling was generally less the 3,000 dpm/100 cm^2, trusses and beams ranged from 3,000 to 5,000 dpm/100 cm^2 and could be reduced by wiping. A moist wipe of masonry and wallboard walls generally reduced the contamination to below 5,000 dpm/100 cm^2.

Approximately 11,000 ft^3 of surface soil previously contaminated with phthalates were removed and disposed of as hazardous waste. Nonessential piping and four waste water tanks used for storing and processing contaminated water were removed. The decontamination work permitted unrestricted release of the building and surroundings.

Lessons Learned

- The history of a facility and knowledge of operational personnel should be used in developing decontamination plans. The change in regulatory criteria and implementation of new criteria must be perceived.
- Work closely with interested agencies. Maintain close communications and keep all interested agencies involved with the planning and progress. Initial planning, facility characterization, preparation of specifications, monitoring of contractors, and QA, schedule and costs are the building blocks of a successful and cost-effective program.
- While it is important to characterize the levels of contamination in a facility prior to initiating decontamination, it is neither cost-effective nor reasonable to try to identify all levels and areas of contamination prior to having performed much of the decontamination.

3.4 EXPERIENCE WITH D&D OF BERYLLIUM CONTAMINATED FACILITIES

Facility Description

Machining and milling operations with depleted uranium and beryllium have been conducted in Building 312 at the Materials Technology Laboratory in Watertown, Massachusetts.

Restoration Project

Morrison Knudsen and Scientific Ecology Group (SEG) are jointly conducting remediation of Building 312. Although the details of the project have not yet been published, Alex Feldman of SEG provided some information on the work. The primary goal is to remove the depleted uranium. The approach is to perform characterization, sampling, remediation, and packaging for the waste shipments.

Problems/Successes

Most of the beryllium contamination is removed along with the uranium contamination. Contamination from smooth surfaces is removed by wet wiping with household cleaners. After using a HEPA filtered vacuum, walls and ceilings are removed and permanent surfaces are scabbled. Respirators and protective clothing are required if smearable beryllium contamination exceeds 1 $\mu g/100\ cm^2$. To measure smearable contamination levels, swipes with ashless paper are dissolved and submitted for analysis by atomic absorption. Results require 2 to 4 days following submittal of samples. Because results from air samples require approximately 2 weeks, air samples provide confirmatory information on procedures.

The wastes are treated as beryllium-tainted low-level radioactive waste and are classified in accordance with 40 CFR 261.33E (see Appendix A for interpretation of waste categories). They will be transported to EnviroCare in Utah for final disposal.

Beryllium has been handled safely (Preuss 1985) through compliance with 1949 adopted threshold limits of 2 $\mu g/m^3$ daily weighted average and 25 $\mu g/m^3$ as peak value for 30 minutes. The ambient air standard is 0.01 $\mu g/m^3$. These limits have been part of the Occupational Safety and Health Administration (OSHA) standards since 1970.

The lack of experience and knowledge about the toxicity of beryllium and safe handling methods of beryllium in the 1940 and 1950s resulted in unmitigated exposures in excess of the above standards, numerous cases of beryllium disease, and deaths. The success in producing and using beryllium in numerous applications with minimum incidences of beryllium illness, mainly

associated with accidental exposures, shows that the potential health hazard can be well-contained and that beryllium can be produced and fabricated without undue risk to employees or the general public when current exposure limits are followed.

In general, cleaning methods, such as those described by Chako[(a)], must be utilized during D&D of buildings and equipment used for beryllium processing that do not give rise to airborne beryllium dust, expose persons to airborne concentrations of beryllium in excess of the standard, or result in contamination of the individuals or their personal clothing.

There is no United States standard for surface cleanliness for beryllium. A Brush Wellman recommended standard of cleanliness for beryllium on non-porous surfaces is 25 $\mu g/ft^2$ or 270 $\mu g/m^2$. A wipe test procedure to determine surface cleanliness is provided in Appendix B. After this level of cleanliness is achieved, no further decontamination is necessary. Experience indicates that this level of residual contamination does not pose an airborne exposure potential in excess of the standards for normal handling.

Please note that surface contamination is not a quantifiable indication of airborne concentration. Because of the variability in the types of activities which could dislodge the contamination and the size of the particles involved, it only represents a crude indicator of exposure potential. Large non-respirable particles picked up using a wipe test will cause misleading results.

Though unusual, the potential for a significant quantity of beryllium to be imbedded in a surface does exist under select conditions and would not necessarily be revealed from a wipe test. Such penetration is generally associated with excessive surface contamination and usually becomes obvious during cleaning and physical inspection. Health concerns for the release of imbedded beryllium will usually arise during activities such as machining, grinding, sanding, polishing, abrasive cleaning, destructive maintenance, or

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(a) Letter and Attachments, dated March 18, 1993 from L. A. Chako, Brush Wellman Inc., Elmore, Ohio to E. R. Gilbert, Pacific Northwest Laboratory, Richland, Washington.

welding. These may generate airborne concentrations of beryllium in excess of occupational standards.

Inhalation of concentrations of beryllium in excess of the Occupational Standard described below can cause serious lung disorders. The OSHA of the U.S. Department of Labor has established mandatory standards for occupational exposures as set forth in 29 CFR Section 1910.1000, Table Z-2. In summary, this regulation provides the following:

1. Daily weighted average exposure over an eight-hour day may not exceed 2.0 $\mu g/m^3$ of air.

2. Short term exposures above 5.0 $\mu g/m^3$ of air, but not greater than 25.0 $\mu g/m^3$ of air is permissible for a total of no more than 30 minutes during an eight-hour working period.

The Atomic Energy Commission method for air sampling is provided in Appendix C.

Lessons Learned

- For D&D of beryllium facilities, a minimum of high efficiency full-face mask respirators should be worn during the entire decontamination process. Workers utilizing respiratory protection should be adequately trained and properly fit-tested. If potential exposures exceed 20 $\mu g/m^3$ of air, demand air line breathing air respirators must be worn.

- It is necessary to provide protective clothing to prevent contamination of the employee's personal clothing with beryllium. Disposable outerwear with snug-fitting openings is suggested. Contaminated disposable clothing must be properly containerized and disposed to prevent secondary exposures.

- Isolate the beryllium D&D work area, including heating/ventilation systems, and restrict access using barriers designating it as a mandatory respirator zone.

- For beryllium-contaminated equipment, carefully evaluate the potential for internal contamination where a mass of beryllium-containing material could have accumulated.

- Dry vacuum beryllium-contaminated areas using a vacuum cleaner with a HEPA filter or equivalent system. Never clean using compressed air or dry sweeping.

- During D&D of beryllium facilities, wet-clean areas with water. Metal equipment may be wiped with a solvent as necessary. If solvent is used, proper personal protective equipment must be worn in accordance with the

solvent manufacturer's recommendations. Refer to the MSDS[a] for proper waste disposal practice. If residual loose particulate inadvertently remains after vacuuming, it is advisable to mist surfaces before hose cleaning or high pressure washing to minimize the release of particulate into the air from initial water impact. Repeat the aforementioned procedure up to three times, if necessary. WARNING: Do not spray water or sponge off electrically energized equipment. All electrical equipment which might be affected must be locked out and tagged according to good safe practice.

- Paint to bind remaining particulates if the recommended standard of cleanliness cannot be achieved.

(a) Kolanz, M. and T. N. Markham. 1992. Material Safety Data Sheet - No. M100, Brush Wellman, Inc., Elmore, Ohio.

4.0 SUMMARY OF LESSONS LEARNED

Many government and utility facilities have and will be decontaminated and decommissioned. It is important that each should benefit from the experiences and methods developed in prior projects. The following subsections summarize some of the lessons learned that should be considered in the D&D being planned for the RFP. These are grouped into the general categories of planning, QA/safety/documentation, characterization, dismantlement/size reduction, decontamination, and waste management.

4.1 PLANNING

- Start planning for the management of waste streams long before you start generating them. Developing management plans for "special-case waste" takes much longer than generating it. Because facilities and equipment are generally not designed for D&D, careful reviews are necessary to determine the D&D methods that will be successful. Adequate lead time should be provided in planning for the procurement and fabrication of specially designed containments or equipment. Design of future equipment and facilities should incorporate D&D requirements.

- Always, always, always expect and plan for the unexpected. Just like Cracker Jacks™, there is a surprise in every package! Don't work in the margins of your safety envelope. Contamination in glovebox hold-up areas complicate decontamination efforts. Facility and equipment drawings and specifications should be carefully consulted when determining waste streams because hazardous materials such as lead, mercury, and cadmium are often hidden in various places that are not obvious. Make note of unusual isotopes, particularly neutron emitters, that may be present in special waste streams such as from laboratories or shops. These isotopes can cause anomalous assay results if they are not identified.

- When planning for the management of waste it is important to consider that there are often more stringent regulations for shipping hazardous and/or radioactive waste than for disposing of the waste. The work will progress much more smoothly if the waste package designs are reviewed with all interested parties e.g., DOE, DOT, and NRC. During the planning stages, the project must be prepared for regulatory changes and revised regulatory interpretations by NRC, DOE, and DOT. Work closely with interested agencies. Maintain close communications and keep all interested agencies involved with the planning and progress. Initial planning, facility characterization, preparation of specifications, monitoring of contractors, and QA, schedule and costs are the building blocks of a successful and cost-effective program.

- Operations of D&D must be planned to ensure compliance with all applicable waste management requirements, e.g., TRU waste packaging, certification, storage, transport, and disposal criteria. These requirements may severely limit the general D&D approach as well as specific technology options.

- Planning must include characterization of the types, extent, and levels of contamination. It must consider inputs (facility, mixed waste, soil, etc.) and outputs (future site uses, recycling, future regulatory restrictions). To be responsive to regulatory compliance, it must set cleanup standards. The cost and schedule basis must factor in experience, results of completed D&D projects, new regulations, but even then may range by at least a factor of four. Prohibitive costs and schedule may require new innovative methods for decontamination, fixation and stabilization, and dismantlement. Goals need to be frequently reevaluated for cost-effectiveness. Methods of packaging will depend upon materials disposition. Possible dispositions include reuse, recycle, or disposal with no regard for residues material recovery.

- Particular care must be taken when planning for the packaging of TRU mixed waste (TRU waste that is also a hazardous waste). For example, the Washington State Department of Ecology has decided that repackaging hazardous waste constitutes treatment which requires a Resource Conservation and Recovery Act permit.

- A requirements analysis is very valuable in avoiding difficult situations during decommissioning and ensuring that waste packages can be shipped for disposal. The requirements analysis clearly identifies all requirements related to burial, shipping, packaging, decontamination, characterization, equipment removal, and other program operations. The requirements should be considered in this specific order to ensure that the end product of the D&D operations is a waste package that can be buried or stored for later retrieval (Thompson and Kurtz 1982).

- Decontamination and decommissioning operations must be planned to ensure compliance with all applicable waste management criteria. The DOE/NRC/EPA/ State/County/City release limits for separating wastes into categories of unrestricted recycle, LLW, TRU, high level wastes, etc. are not in agreement. Regulations from the different governments and agencies provide conflicting and inconsistent requirements. This may severely limit the general approach as well as specific technology options. Volume reduction by incineration is becoming increasingly difficult to license.

- Former staff provide valuable insights. The use of experienced personnel are very important to the success of D&D. Past records of contamination and spills have been useful in planning decontamination procedures. The D&D planning requires characterization of contamination inventories and distribution.

- The use of a closed-circuit television to monitor D&D operations can significantly increase efficiency through improved communications among those performing and those directing the work.

- A staging area is needed for meeting, planning, training, reviewing, administration, etc. A three-zone exit is effective for controlling contamination of personnel, equipment packages, and tools. Two independent exits are needed to accommodate accidents in one of the exits.

- In some cases, decontamination can be first applied to the removable equipment to free up larger working areas and to prevent recontamination during work on the building structurals and utilities. These more difficult areas are usually decontaminated last.

- Industry is developing expertise in the area of decontamination and decommissioning. It is assuming a major role in the D&D of government facilities and can become an important factor in planning the resources for new projects.

- Personnel protective clothing and respirator equipment are key items that require careful planning. Where permitted, portable battery-powered air-purifying respirators can be used to avoid resuspension problems caused by dragging fresh air hoses through contaminated areas, or carrying the weight of a portable air supply.

- Provisions for containment, wherever loose radioactive material is handled, will provide significant savings in decontamination and cleanup costs.

- In some cases, it has been cost-effective to reduce contamination in areas that will not be reused to as low as reasonably achievable (ALARA), and remaining contamination is permanently sealed so that areas can be reused with minimal restrictions.

- During decommissioning, construction of a new synthetic-lined lagoon can be very effective for temporary placement of process wastes removed from a lagoon contaminated from uranium processing.

- While it is important to characterize the levels of contamination in a facility prior to initiating decontamination, it is neither cost-effective nor reasonable to try to identify all levels and areas of contamination prior to having performed much of the decontamination.

- Isolate beryllium D&D work areas, including heating/ventilation systems, and restrict access using barriers designating it as a mandatory respirator zone.

- For beryllium-contaminated equipment, carefully evaluate the potential for internal contamination where a mass of beryllium-containing material could have accumulated.

4.2 QUALITY ASSURANCE/SAFETY/DOCUMENTATION

- Keep careful track of fissile material inventories in waste containers. Also, it is probable that the final container assay, which is usually considered to be the record value for the container, can vary considerably from the sum of the packages that were put into the container.

- Always confirm old fissile material holdup values for components by assay. Reassay subcomponents as often as necessary to trace the flow of fissile material.

- Specific environmental standards and broad federal guidelines governing release of residual radioactive contamination have not been issued, but are needed to guide D&D (Shum and Neuder 1990).

- High-efficiency particulate air filters pose a number of problems. They are typically considered to be noncertifiable TRU waste because of concerns about small particle loading. They may also be considered to be hazardous waste because of operations that were conducted in the areas serviced by the filters. The exact composition of chemical contamination on the filters is usually difficult to determine. HEPA filters concentrate TRU waste material thus presenting a potential problem for criticality safety when packaged as waste. Also, the combination of TRU waste and chemical contaminants on the filter can give anomalous readings during assay as by alpha-n reactions.

- The use of surface-fixing films and strippable coatings is very useful for contamination control during D&D operations. However, at least some of these films are considered to be good neutron moderators, and disposal geometry can be a concern if these are stripped and wadded into a configuration that resembles a sphere. Criticality safety specialists should be consulted before using any of these films with fissile material. Also, the films may be considered a hazardous waste, and compatibility of the fixative with all waste disposal criteria must be addressed.

- Because there have been many changes in regulations, new experiences with D&D, and new commercial products and services, an updated decommissioning handbook in the form of an electronically retrievable data base is needed. ORNL is preparing a new D&D handbook.

- Most D&D projects have required meticulous planning, procedures, reviews, and training. Characterization of the contamination and project requirements are essential to ensure that the generated waste products can be classified and disposed in compliance with all regulations at all levels of government. Radiation work procedures are developed and the work performed in compliance with radiological monitoring, security, criticality safety, materials management, and decontamination standards. Methods are implemented to ensure ALARA exposures, adequacy, consistency, change approval, and reporting. Even if the facilities are to be used for other DOE projects, contaminated surfaces would usually be painted only after reasonable efforts were

made to reduce contamination levels to the standard for unpainted contamination. Painted surfaces are documented for future reference.

- Retrievable storage boxes may not conform to current transport and WIPP disposal criteria. The D&D operations must be planned to ensure compliance with all applicable waste management criteria, e.g., criteria for transport and disposal containers. This may severely limit the general approach as well as specific technology options.

- The use of independent contractors to verify remaining contamination provides assurance of monitoring results and additional documentation for future reference. To increase the odds of not missing contamination, all surfaces may be surveyed at least three times with three portable instruments having different detection characteristics.

- For D&D of beryllium facilities, a minimum of high efficiency full-face mask respirators should be worn during the entire decontamination process. Workers utilizing respiratory protection should be adequately trained and properly fit-tested. If potential exposures exceed 20 $\mu g/m^3$ of air, demand air line breathing air respirators must be worn.

- It is necessary to provide protective clothing to prevent contamination of the employee's personal clothing with beryllium. Disposable outerwear with snug-fitting openings is suggested. Contaminated disposable clothing must be properly containerized and disposed to prevent secondary exposures.

4.3 CHARACTERIZATION

- Initial assay characterization of the radioactive materials is very important to identify locations of contaminants and is essential for planning and monitoring the progress in decontamination. Planning must include contingencies to deal with unexpected materials, e.g., plutonium fluoride where plutonium oxide was expected. Characterization can be effective in controlling problems from unknown and inconsistent constituents in proprietary commercial products. Unexpected contaminants should be anticipated.

- The development of a nondestructive assay capability can enable separation and classification of waste packages. Procedures for direct-reading assay with instruments can enable residual contamination and TRU waste content to be measured. Without protection, monitoring instruments can become contaminated. A thin polyester film can effectively protect instruments.

- While it is important to characterize the levels of contamination in a facility prior to initiating decontamination, it is neither cost-effective nor reasonable to try to identify all levels and areas of contamination prior to having performed much of the decontamination.

4.4 DISMANTLEMENT/SIZE REDUCTION

- Formerly, the easiest and cheapest approach to D&D appeared to be minimal size reduction with the resulting debris packaged for disposal. However, new disposal requirements may require size reduction.

- A large glovebox can effectively contain loose contamination during volume reduction operations. All equipment and debris should be removed from gloveboxes and other similar types of equipment before size reduction for contamination control. The removal of large components from gloveboxes without spreading loose contamination can be accomplished through a bagout port. Lots of contamination can hide in or under the smallest item that is left in a glovebox. Plasma cutting of gloveboxes generates less smoke than torch cutting.

- If gloveboxes cannot be decontaminated for release as LLW, then volume reduction can be accomplished by reducing gloveboxes and equipment into small pieces and loading them into 55-gal drums. Temporary enclosures can be used to control contamination during size reduction operations.

4.5 DECONTAMINATION

- When decontaminating, have a variety of techniques available. There are many methods for decontaminating equipment and facilities (Allen 1985; Hermetz 1986; Remark 1989; Kaiser Engineers Hanford Company 1993). Choose techniques for specific decontamination jobs that are best suited to that particular job. Do not install one or two pieces of decontamination equipment and try to force-fit these to all decontamination jobs.

- In some cases, complete decontamination has been achieved by chemical decontamination. Gloveboxes and other large TRU-contaminated components can be turned directly into LLW by in-situ decontamination (Allen and Hazelton 1984). The increase in allowable maximum TRU waste level from 10 nCi/g to 100 nCi/g as defined in DOE Order 5820.2 improves the feasibility of this process. It is, however, a common practice from the perspectives of waste volume generation, cost, and schedule to fix contamination on glovebox surfaces and proceed with dismantlement rather than to attempt to clean surfaces to unrestricted release levels prior to dismantlement. This is particularly true if there is substantial contamination holdup in inaccessible areas that could prevent decontamination to less than TRU waste levels without generating excessive volumes of liquid waste, as well as increasing decontamination time and cost.

- If conventional decontamination methods do not adequately reduce contamination levels in gloveboxes, contamination fixation may be required to control the spread of contamination during glovebox, equipment, and piping removal.

- Contamination in cracks and crevices can make it difficult to achieve building goal levels. Scarifying may be required to decontaminate concrete surfaces. The decontamination of block walls can be very difficult. There may be residual contaminated areas that cannot be eliminated without demolishing the wall.

- Strippable fixatives can be very effective for contamination control and as a decontamination method to remove smearable contamination. A removable fixative applied to freshly decontaminated areas may prevent recontamination. Where necessary, fixatives should be applied using a low pressure paint spray (pressure pot) system to minimize contamination resuspension. The decontamination of smooth vertical surfaces and inaccessible areas can be facilitated by using cheese cloth that is sprayed with the fixative. Criticality safety concerns and waste disposal criteria must be considered when employing fixatives.

- Recontamination from radioactive materials trapped in inaccessible crevices and holdup areas is a major problem. One approach is to apply a coating to fix the contamination, and clean small areas that are then coated to prevent recontamination.

- Regulatory revisions may preclude some effective methods of decontamination such as dry cleaning with Freon 12 and 113 or surface fixation with paints and foams, Pb-base paints, and or substances that decompose to form hydrogen-generating compounds. Unexpected contaminants, such as, ^{137}Cs (B Plant, Purex), Promethium (B Plant, Purex), and Am (Z Plant), should be anticipated.

- Decontamination is feasible with limited quantities of liquids, but requires innovative tools and techniques. Preliminary tests and demonstration of methods is essential. Decontamination efforts may drive contaminants further into the structure. Contamination that may be trapped between fixtures and the mounting surface can be resuspended during D&D operations, causing a serious airborne problem. Successful decontamination may require fixation of loose contamination, otherwise cleaned areas may become recontaminated. Experienced and skilled decontamination workers are important.

- Paint applied to protect surface from contamination needs to be high density. Porous paint may not prevent contamination of substrate (Meigs 1987). Tests specified by ANSI N5.12-1974 should be applied to protective painted surfaces

- Beryllium-contaminated areas should be dry vacuumed using a HEPA filter or equivalent system. Never clean using compressed air or dry sweeping.

- During D&D of beryllium facilities, wet-clean areas with water or metal equipment may be wiped with a solvent as necessary. If solvent is used, proper personal protective equipment must be worn in accordance with the solvent manufacturer's recommendations. Refer to the Materials Safety Data Sheet published by Brush Wellman, Inc. for proper waste disposal practice. If residual loose particulate inadvertently remains after

vacuuming, it is advisable to mist surfaces before hose cleaning or high pressure washing to minimize the release of particulate into the air from initial water impact. Repeat the aforementioned procedure up to three times, if necessary. WARNING: Do not spray water or sponge off electrically energized equipment. All electrical equipment which might be affected must be locked out and tagged according to good safe practice.

- Paint to bind remaining beryllium particulates if the recommended standard of cleanliness cannot be achieved.

4.6 WASTE MANAGEMENT

- All waste streams should be identified and thoroughly characterized. Waste management and operations staff should work together on this so that all of the regulatory concerns of waste management are considered and the likelihood of finding certain types of waste is determined. Also, the regulations of any states that will be involved in managing the waste must be considered as well as Colorado regulations. For example, if any waste is destined for storage, treatment, or disposal in Washington State, the waste stream characterization must include the peculiar provisions of Washington State regulations as well as the Colorado regulations.

- Transuranic waste must either be packaged to comply with the WIPP and TRUPACT requirements in place at the time the shipment is to occur, or packaged in a manner that facilitates retrieval and repackaging. Considering the history of the WIPP waste acceptance criteria and the TRAMPAC, the latter approach is recommended.

- The combination of beryllium and uranium in wastes generated during the decommissioning of Building 865 and Building 444 may cause the wastes to be classified as mixed. As of now there are no approved methods for the disposition of mixed wastes.

- Chromium solutions generated by the decontamination of contaminated stainless steel components may generate mixed wastes, for which there are now no approved methods for disposition.

- If gloveboxes or other equipment contain lead, then the materials may become classified as mixed wastes, for which there are now no approved methods for disposition.

- WIPP does not accept TRU waste (and others) that contain combustible or gas-generating materials such as plastics, foam, etc. A common practice in the packaging of retrievable TRU waste has been to apply urethane and other foams and paints to fix surfaces and to secure packages. It is also a common practice to seal TRU waste in polyethylene blankets. Some TRU waste likely contains organic gaskets and seals that could become gas-generating sources. Note: Before using foam or strippable paint, that may be subject to long-term radiolysis during TRU waste disposal,

as a fixative and packing additive, materials permitted in transport and disposal of TRU waste must be reviewed. More effective methods for decontamination and size reduction may now be available.

- Retrievable TRU packages are frequently outside the range of acceptable packages acceptable by WIPP. Common practice has been to enclose gloveboxes and other contaminated equipment now in large retrievable wooden or metal boxes. These will likely require size reduction, volume reduction (e.g., compaction, cutting, incineration, recovery (Kazanjian and Killion 1979), melting (Levitz et al. 1975)), and repackaging to meet current WIPP requirements.

- The DOE/NRC/EPA release limits for separating wastes into categories of unrestricted recycle, LLW, TRU, high level wastes, etc., are not in agreement. Regulations from the different governments and agencies provide conflicting and inconsistent requirements.

- Continued surveillance is required for sites or buildings that are not decommissioned for unrestricted release or to ensure that underground contamination is not migrating.

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PRIORITY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 2 1992

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

RECEIVED
NOV - 3 1992

Mr. Robert Chase
Chief, Risk Management Office
Department of the Army
U.S. Army Laboratory Command
Materials Technology Laboratory
Watertown, Massachusetts 02172-0001

Dear Mr. Chase:

Thank you for your letter of October 26, 1992. As we understand from your letter and a telephone conversation of October 28, 1992, your facility is undergoing a decommissioning and you need to classify the regulatory status of some beryllium contaminated equipment for waste disposal. Based on your description of the two categories of wastes generated at your facility, we conclude neither meets the definition of a listed hazardous waste. Our rationale for this conclusion is described below.

PROJ MGR	✓
RSHM	✓
SSHO	✓
BUS MGR	
PURCH	
CONTRACTS	
QA/QC	✓
GEN SUPT	✓
CONTROLS	
PROJ ENGR	✓
[illegible]	✓
[illegible]	✓
[illegible]	✓
RE & CO	✓
RE / TS	✓
RE / HPS (R)	✓
RE / HPS (E)	✓
RE / RWC	✓
AMSC	
FILE: [illegible]	
FILE: [illegible]	✓

J. J. Schmuck
Todd Eaton

In your Category 1 scenario, two glove boxes became contaminated with beryllium metal powder that was then used to form metal alloys. The wastes found in the glove boxes or the contaminated glove boxes themselves are not considered a listed waste. The P015 listing in 40 CFR 261.33(e) (beryllium dust) only applies to the powdered metal when disposed of unused. The powdered beryllium in this case has been used (when processed in the glove boxes), so the residuals formed after use (your Category 1 equipment) do not meet the listing description.

In your Category 2 scenario, beryllium particles are found on metal machining equipment as well as filters, cyclones, and blowers connected to a vacuum exhaust system. The beryllium residue was created by the machining of solid beryllium metal and beryllium alloys.

In this instance, the beryllium found on the machining equipment and air exhaust system is not considered a listed hazardous waste. The listing in §261.33(e) applies to beryllium dust that is an unused commercial chemical product, not beryllium particles created in normal machining operations (unless the purpose of the operation is to create the beryllium dust or powder as a commercial chemical product).

REGARDLESS OF THIS POLICY STATEMENT BY EPA, LLRW (WITH BE) MAY NOT BE ACCEPTED BY BARNWELL FOR DISPOSAL. HOWEVER ENVIROCARE WILL ACCEPT FOR DISPOSAL AS LLRW. THUS WE NEED TO DIFFERENTIATE [illegible] FOR PURPOSES OF [illegible]

03/30/93 16:58

Please note that if any of the abovementioned wastes exhibit a characteristic of hazardous waste described in 40 CFR 261.20 - 261.24 (ignitability, corrosivity, reactivity, or toxicity characteristic), the waste(s) may still be considered hazardous wastes. In addition, you should be aware that the State of Massachusetts may have regulations for the waste(s) more stringent than those of the Federal government. Please contact the State to find out if the State's definitions are different from those of EPA.

Thank you for your inquiry. If you have any additional questions on this topic, please contact Ron Josephson of my staff at (202)260-6715.

Sincerely,

Rick Brandes

Rick Brandes
Chief
Waste Identification Branch

cc: Ed Abrams
Ron Josephson
Wanda Levine
Mark Badalamente, OGC (LE-132S)

BRUSHWELLMAN
ENGINEERED MATERIALS

Procedure

Title: WIPE TEST OF SURFACE DUST ON BERYLLIUM SHAPES OR CONTAINERS.

#BW/E 0310-IN

PURPOSE: To establish a standard procedure concerning periodic checks for beryllium dust levels on shapes or containers, and to meet customer specification requirements. The test frequency will be dictated by the customer specification.

SCOPE: This procedure is performed by Quality Assurance Inspectors, either in the QA inspection area or on the shop floor, to determine if any beryllium surface dust can be detected on shapes just prior to packing the parts in boxes for shipment. This procedure is generally initiated by customer requirements and may also be specified for containers (drums, wrapping, etc.) prior to shipment.

FORMS: Analytical Chemistry Report, form #29 (example attached).

Wipe Test Log Book (not shown).

EQUIPMENT:

1. #41 Ashless filters (11.0 cm) or equivalent.
2. Cellophane bags (5-3/4" x 7-3/4") or equivalent.
3. Standard manila specimen envelopes.
4. Distilled water.
5. Tweezers (optional).

Safety Equipment:

1. Brush Wellman supplied clothing.
2. Safety glasses.

Approvals:	Preparers	Page 1 of 4
Env. Control	Personnel	Issue Date: 1/11/8
	Dept. Mgr(s).	Rev. Date:
	QA Mgr.	Revision# 0

Title: WIPE TEST OF SURFACE DUST ON BERYLLIUM SHAPES OR CONTAINERS.

#BW/E 0310-IN

PROCEDURE:

1. The Inspector should thoroughly wash his/her hands with soap and water. Avoid direct handling of the part at all times to minimize potential exposure to hazardous dust.

2. Wet a filter with distilled water and wipe the entire outside surface. To avoid contact with potential surface dust, the wet filter must be held with a second filter paper. Some Inspectors prefer to hold the second filter with tweezers. Work from the top down.

3. The filter shall immediately be placed in a new clear cellophane bag to avoid contamination.

4. Using a clean filter, repeat steps 2 and 3 for all remaining surfaces.

5. The cellophane bag is to be folded once and placed into a standard manila specimen envelope to avoid direct handling. The envelope should be sealed and identified with:

   Lot number.
   Serial number.
   Sales order number.

6. Calculate the total surface are wiped (in square feet). Very often the surface area will have been previously calculated. Check the drawing, inspection report, or consult with QA Supervision.

   Fill in the Analytical Chemistry Report as shown on page 3.

   Log the submission in the Wipe Test Log Book (not shown), which is kept in the Inspection area.

   Submit the sample to the Analytical Lab.

   6.1. The surface area (sq. ft.) is not to be listed on classified shapes. The Analytical Laboratory will report total ugm and the ugm/sq.ft. is calculated in the Quality Assurance Inspection area.

Title: WIPE TEST OF SURFACE DUST ON BERYLLIUM SHAPES OR CONTAINERS.

#BW/E 0310-IN

7. Acceptance is to be based on the requirements of applicable Brush or customer specifications (generally 25 ugm/sq. ft. max.). If the acceptance standard is not met, the part will be returned to the last operation for cleaning and then resubmitted. Once again, avoid direct handling to minimize exposure to hazardous dust.

8. File the completed chemistry report in the Quality Assurance Deparmtent Sales Order file.

9. When this procedure is applied to drums or wrappings for shipment, the Inspector is to mark off a one square foot area on the outside surface.

BRUSHWELLMAN
ENGINEERED MATERIALS

Procedure

Title: WIPE TEST OF SURFACE DUST ON BERYLLIUM SHAPES OR CONTAINERS.

#BW/E 0310-IN

ANALYTICAL CHEMISTRY REPORT

To: Production _____ Date _____

Quality Assurance X Sample No _____

Engineering _____ Chem. Lab. No. _____

File Spec. Lab. No. _____

Sampled By _____ Gal., liters or lbs. _____

Sample Identification and Description WIPE TEST

Lot #, Serial #, sq. feet

	Be			pH			H_2SO_4		
(HCl)	BeO			SOLIDS			$K_2Cr_2O_7$		
(BM)	BeO			Co			NaOH		
	Al			Cu			HNO_3		
	Fe			F			Radiograph		
	Mn			Ca			Solve Analysis (State fraction)		
	C			SO_4			CO_2		
	N			Si			NH_3		
	HF			Normality			Na		
	NH_4F			LOD			LOI		

Date Analysis Required ASAP

Instructions Beryllium in micrograms

Checked By _____ Analysis By _____ Date _____

Account Sub	Class	51	52	53	54	55	56	57
	Quantity							
Work Order	Class	58	59	60				
See NOTE:	Quantity							

USE WORK ORDER NUMBER FROM THE PART(S) BEING TESTED

BRUSH WELLMAN INC. Elmore, Ohio

FORM 29 FRANKLIN 8 '78 10M

Approvals: D. P. Farm 1/11/81	Preparers	Page 4 of 4
Env. Control	Personnel	Issue Date: 1/11/8
	Dept. Mgr(s).	Rev. Date:
	QA Mgr.	Revision# 0

APPENDIX C

THE ATOMIC ENERGY COMMISSION METHOD FOR AIR SAMPLING

The Atomic Energy Commission (AEC) method of monitoring was formalized in 1956 and is used by the industry to determine the degree of compliance to the 2 $\mu gBe/m^3$ standard in beryllium production facilities. This method makes use of two high-volume samplers and a 4 in. Whatman #41 filter[a] paper. Two types of total dust samples are collected: 1) General Area--usually varying from 15 minutes to an hour in duration; and 2) Breathing Zone--varying from about 2 to 10 minutes in duration. The results of General Area and Breathing Zone samples are used along with a time and motion study of the worker's job to calculate his daily weighted average for a 3-month period.

The personal sampling methods differ from the AEC method in that the sampling equipment used in the personal methods is worn by the workers during the work shift. With dusts, both total and respirable personal samples may be obtained.

PERSONAL TOTAL SAMPLE

A personal total sample collects all particle sizes of dust in the air to which the worker is exposed. Total samples are collected directly on a 37 mm, 0.8 μm pore size membrane filter in a plastic cassette worn on the lapel. A MSA pump is used to pull the air through the filter at a flow rate of 2 L/min.

(a) Mention of company or product names is not to be considered as an endorsement by NIOSH.

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